Tradability, Productivity, and Understanding International Economic Integration

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Abstract:

This paper develops a model to study features of international economic integration in goods markets. Empirical work arising from recent episodes of goods market integration in Europe and in North America suggests some surprising observations: while quantities of trade have increased significantly, especially along the extensive margin of goods that previously were nontraded, there has been limited or even negative price convergence. As we show in a model where the choice of trading internationally is endogenous, the entry of new traders at the extensive margin may be a key to understanding the price facts as well as the quantity facts. The key features are trade policies that impact the fixed costs of trade as well as per-unit tariffs, and heterogeneity among firms in terms of the per-units costs of trade they face. The latter feature suggests that trade reform can encourage entry of new traders with higher than average price wedges between national markets. Theoretical results raise a basic question regarding the appropriate metric for gauging success of efforts to promote economic integration.

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I. Introduction

Several considerations motivate the current interest in international macroeconomics regarding the segmentation and integration of national markets. Firstly, the broad literature on pricing to market and deviations from purchasing power parity relies upon the assumption that national markets are segmented, so that firms have the ability to charge different prices in different countries. Secondly, market segmentation also has implications for quantities, and the existence of goods that are nontraded is essential to many basic conclusions in the field such as current account determination. Thirdly, given recent policies aimed at promoting international market integration in North America and in Europe, there is heightened interest in understanding the implications of such integration policies.

Recent experiences with policy reforms have provided some new evidence which is quite difficult for our standard open economy macro models to explain. In particular, we refer to the Canada-U.S. Trade Agreement (CUSTA) and the North America Free Trade Agreement (NAFTA) aimed at promoting economic integration in North America in the early 1990s, and the Single Market Program (SMP) in the early 1990s and the European Monetary Union (EMU) in 1999 designed to further consummate economic integration in Europe. One set of facts involves quantities: trade volume seems to respond more significantly than standard models predict, and much of the increased trade volume occurs in the form of new goods that were not previously traded, rather than increased intensity in trade of previously traded goods (Kehoe and Ruhl, 2002). This is often referred to as the extensive margin of trade. A second set of facts refers to prices. Recent research by Engel and Rogers (2004) suggests that law of one price deviations in Europe stopped converging in 1999 and may even be diverging. A similar conclusion is suggested for North America, where price convergence appears to have stopped in the early 1990s, and there is divergence in many classes of traded goods.

Explaining both these quantity and price facts of economic integration presents a modeling challenge. In general, our open economy macro models are ill-suited for studying the process of economic integration, since they tend to take market segmentation as given, simply assuming firms can set different prices in different national markets. While standard macro models with sticky prices in the local currency can explain some degree of price disparities, empirical research suggests that a substantial portion of these price deviations are due to other unknown factors on the real side of the economy (Engel and Rogers, 1996).

Standard trade theory also cannot explain the full set of facts. Recent advances have been made in modeling the costs of trade, and how they determine the decision of firms to export or not (see Melitz, 2003; Ghironi and Melitz, 2004, Kehoe and Ruhl, 2002; and Ruhl 2003). Emphasis in this literature has been placed on heterogeneity of firms in terms of productivities, where only the more productive firms find it profitable to enter the export market. However, while this approach can explain stylized facts regarding quantities, it is not set up to explain facts regarding price dispersion. It is trade costs that prevent arbitrage and permit wedges to arise between prices across countries. So the standard trade assumption that the heterogeneity among firms is in the form of productivity differences rather than in terms of heterogeneous trade costs tends to imply that there is a uniform price wedge across goods. However, evidence indicates that there is a great deal of heterogeneity among goods in terms of their cross-country price wedges (Crucini, Telmer, and Zachariadis, 2001). Some goods have large deviations from the law of one price; others have more moderate deviations.

To address the behavior of price deviations, we depart from the practice in trade theory of focusing on firm heterogeneity in the form of productivity, to instead focus on the role of trade costs and the heterogeneity in this dimension This choice is motivated by a range of recent empirical evidence highlighting the importance of trade costs. Hummels (1999, 2001) has emphasized that such costs—including tariff and nontariff barriers, shipping costs, and other associated costs of marketing and distribution—vary greatly across classes of goods and play an important role in trade decisions. Collecting detailed trade data for individual goods, he finds that freight costs alone can range from more than 30 percent of value for raw materials and mineral fuels down to 4 percent for some manufactures. And in a broad survey of trade cost evidence, Anderson and van Wincoop (2003) likewise reach the conclusion that trade costs are very large and very heterogeneous among goods.

To be more precise, this paper formulates a two-country open economy macro model where each country has a continuum of monopolistically competitive producers which must choose whether to sell in the foreign market in addition to the domestic market. This decision is affected by two types of real trade frictions: one in the form of per-unit (iceberg) trade costs which can vary by good, and the other a fixed cost of international trade which does not depend upon the quantity traded and does not vary by good. The first type of cost is motivated by tariffs and transportation costs, as discussed above; the second type reflects establishment costs or the cost of learning to deal with a foreign language or legal system. While iceberg costs have been favored in recent macroeconomic studies of segmentation (Obstfeld and Rogoff, 2000), fixed costs are essential if some goods are to be nontraded under the assumption of monopolistic competition. A firm will participate in the international market only if it can generate additional positive profits by doing so. Note that the distinction between traded and nontraded goods is endogenous and can shift over time. A distribution is specified for the heterogeneous per-unit trade costs, so that in equilibrium, the nontraded goods will be those with higher trade costs. A version of the model will also consider a distribution of heterogeneous productivities among firms, in which firms with low productivity tend to be the nontradeds.

The model uncovers two distinctions that are important for determining the macro implications of integration. First, it is important whether trade liberalization policies involve reductions in per unit trade costs or the fixed costs. Since prices are set as a markup over per-unit costs—including per-unit trade costs for exports—a policy that reduces per-unit tariffs will have a direct impact in price-setting behavior in the foreign market, and will reduce price-dispersion between the countries. But fixed costs do not enter the price-setting decision, so a policy reducing fixed trade costs does not affect foreign prices. There is no reason to expect such a policy to reduce international price dispersion.

The nature of the trade costs also is important for tracing the implications of the integration policy for quantities. If the policy is aimed at reducing the fixed costs of trade, it is certain to make trade profitable for a range of goods that previously found it unprofitable. Therefore, it will generate a large extensive margin of new trade. On the other hand, a reduction in per unit costs tends to have only limited effects on the extensive margin, as it implies a number of largely offsetting effects on prices and costs which limit the changes in profitability. At the risk of oversimplification, one might summarize that fixed costs of trade are integral to understanding market segmentation in terms of quantities, while iceberg costs are essential for understanding market segmentation in terms of prices.

The second important distinction that the model uncovers is the source of heterogeneity between firms. The question is whether nontraded goods are distinguished from traded goods because they have particularly low productivity, so that they are not profitable to trade; or instead, are they the goods that are particularly difficult to trade over distances or across national borders? The implications of integration policies are very different depending on what determines the tradability of goods, because this determines what characterizes the new goods that become tradable on the extensive margin and how they differ from previously traded goods.

For example, suppose that goods are heterogeneous in terms of trade costs, and a policy generates trade in new goods by reducing fixed costs. Then the new goods being traded systematically will have higher per-unit costs than previously traded goods. After all, this is the precise reason why these goods were previously nontraded. They thus will be goods with higher price wedges between national markets, and their entry into trade will raise the average level of international price dispersion. This particular example may be relevant, in that it coincides with the puzzling data observed in recent market integrations in Europe and North America: a combination of a large increase in trade along the extensive margin, and an apparent rise in average price dispersion. In fact, this model suggests that the two puzzling facts are linked, in that it is the large role of the extensive margin that makes price divergence possible. More generally, the lesson arising from the model is that the larger is the role of the extensive margin in generating goods market integration, the stronger will be the force limiting rather than promoting convergence in prices.

The model indicates that a wide range of results is possible for price dispersion. These range from strong positive convergence in the case of tariff cuts under no trade cost heterogeneity, to zero price effects under fixed cost cuts under no trade cost heterogeneity, to the price divergence discussed above. The more general lesson of the model is that it is incorrect to presume that international integration in goods markets in terms of quantities must coincide with integration in terms of prices. This of course raises questions as to what metrics are most appropriate for gauging integration, and for evaluating the success of recent efforts to promote this end.

II. Empirical Facts

This section summarizes empirical studies of recent trade liberalizations and other policies promoting greater economic integration, some analyzing trade level implications and others analyzing price convergence. These studies point to some surprising facts which suggest features that need to be included in theoretical models of integration.

A. Price Evidence

Foremost among the empirical facts we wish to highlight is the finding that trade liberalizations need not lead to convergence of price levels across national markets. In fact, recent studies indicate that they surprisingly can lead to some price divergence for many classes of goods. This conclusion is suggested by recent studies for two recent attempts at market integration, NAFTA in North America and EMU in Europe.

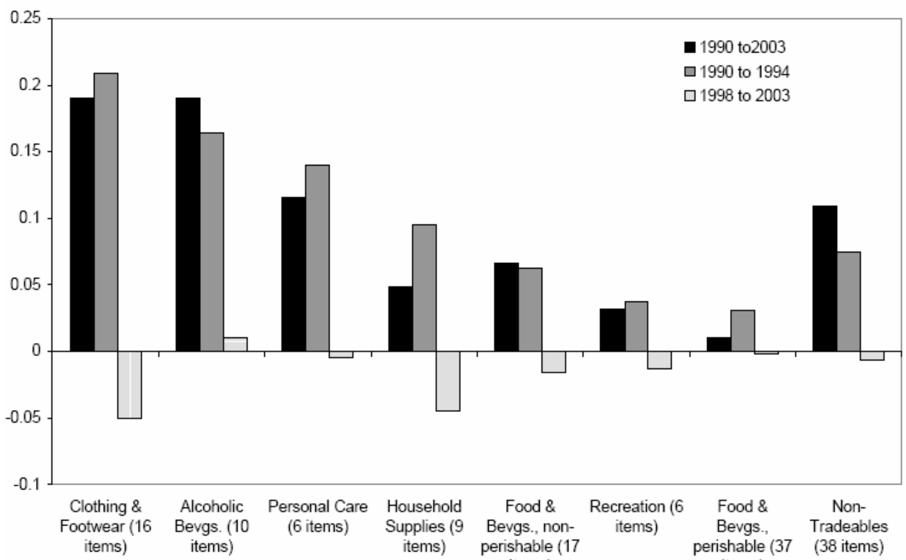
There is an extensive and active literature measuring failures in the law of one price across national markets. One finding over much of this literature is that the law of one price fails also for tradable goods (Engel, 1999). Another is that there is a good deal of heterogeneity in the degree of price deviations at the disaggregated level. Crucini et. al (2001) find that among EU country pairings over the span 1975 to 1990, "…the variance of law-of-one-price deviations across goods is large, with a support on the order of plus or minus 150%," with about as many goods underpriced as overpriced.

The European case is especially surprising, given that an ostensible goal of monetary union was to promote price transparency and arbitrage. Of special interest here is recent research by Engel and Rogers (2004), who examine price dispersion for individual goods from 1990-2003, using data from the Economist Intelligence Unit for about 100 traded as well as 38 nontraded goods, covering 18 cities within the Eurozone and 7 non-euro European cities. Their metric is the mean squared error of price dispersion for each type of good.

Their finding is that while there was price convergence within the Eurozone in the early to mid 1990s, there has been no convergence since the adoption of the euro in 1999. This is a robust result, holding even after controlling for relative wages, relative incomes, VAT taxes, slow adjustment of prices, etc. In fact, examination of their results suggests a general trend of price divergence since 1998 for tradable goods. See figure 1 (a copy of Engel and Rogers figure 3) below. One observation is the heterogeneity in price deviations among different categories of goods. But even more striking is that of their eight categories of traded goods, seven show negative rates of convergence.

Other recent papers support this general conclusion for Europe. Baye et al (2002) examine the effects of EMU on a small set of homogenous goods that shoppers buy online, mostly electronic goods, and find that EMU had little effect on price dispersion. Lutz (2002)

Fig. 1: Change in price dispersion in the euro-11



Source: Engel and Rogers (2004), Table 3.

considers a small set of goods with only post 1999 price survey and finds that EMU has not reduced price dispersion significantly. The European Commission (2004) finds that price indices in the most expensive and least expensive countries were converging in the early 1990s, but stopped converging in the middle of the decade.

A similar conclusion is suggested by examining the effects of trade liberalization in North America following the CUSTA trade liberalizations between Canada and the U.S. in 1989 and with

Mexico in NAFTA in 1993. (See Globerman and Storer (2003) for a more detailed discussion and analysis of this literature discussed briefly below.) For example, Engel and Rogers (1998) update their 1996 study of price dispersion across the U.S.-Canadian border to consider post-NAFTA data. They look at price data for 14 goods categories from 14 U.S. cities and ten Canadian provinces, using a variance measure of relative price deviations around an autoregressive trend, which they regress on distance and a border dummy. They test for the effect of CUSTA and NAFTA by estimating over the subperiods 1978-88 and 1994-97. They find that the conclusion of their earlier paper is still true well after NAFTA, i.e., there is still significant failure in LOP across the national border. The border effect does fall about 20 on average for all goods, but so does the distance effect by a very similar amount, so the authors conclude that trade reform in North America did not affect price deviations. "In the 1990s, it appears that the effects of both distance and the border in segmenting markets have fallen about equally. So, following Helliwell's logic, the decline of the border effect in the 1990s is probably not caused by the free-trade agreement according to our regressions."(page 16) Further, they found that cross-border price variability increased for some very tradable categories, such as clothing and footwear, where one would expect that the trade liberalization should have most likely to encourage price convergence.

Yan (2002) uses paired Canada-U.S. final-user price levels of 168 private business commodities for 1985, 1990, 1993 and 1996. Averaging deviations over goods, she finds a V-shaped pattern where price deviations fell between 1985 and 1990, but then increased in 1993 and 1996. As in the case of Europe, it seems puzzling that price deviations increased following the trade liberalizations, CUSTA in 1989 and NAFTA in 1993-4. A more useful metric is the variance of price deviations, akin to those reported in Engel and Rogers and other papers above. The variances reported in Yan (2002) rise for homogenous traded goods after 1985; in 1996 the overall variance was roughly double its 1985 value. By contrast, the variance of LOP deviations fell significantly for nontraded goods, and fell somewhat for heterogeneous traded goods.[1]

The conclusion arising from these recent studies is that price convergence may be limited following policies encouraging integration, and furthermore, there even appears to be a tendency for price divergence in many tradable groups of goods. One possible explanation suggested by past theoretical literature is the presence of sticky goods prices and fluctuations in nominal exchange rates. Earlier work by Engel and Rogers (1996) found a role for such an explanation, but that accounts for less than half of the LOP deviations. Clearly, we need to find other types of sources for price deviations. Further, this explanation clearly cannot explain increased price divergence across European country borders after the EMU eliminated currency fluctuations in 1999. A second possible explanation is that price convergence in Europe and North America stopped because goods market integration had been completed by that point and price convergence had reached its natural limit. However, the presence of price divergence rather than just a lack of convergence argues against this explanation. Further, evidence of significant additional goods market integration in terms of trade flows suggests that integration had not reached its limit previously. We turn to this quantity evidence next and draw additional lessons.

[1] Yan finds different results between classes of goods when using average price level deviations. But the variance measure she reports is more comparable to the measure in other papers, and avoids the problem that positive and negative price deviations within a group cancel each other.

B. *Quantity Evidence*

Despite the lack of evidence of market integration in terms of price convergence, there does seem to be evidence that trade liberalization does promote integration in terms of increased trade volume. An important aspect of this finding, is that it appears that much of the new trade is in the form of new goods not previously traded. Evidence of this extensive margin of trade is documented in. Kehoe and Ruhl (2002), who study six different trade liberalizations, including NAFTA and the EU Single Market. They define growth at the extensive margin as growth in the share of exports by products accounting for 10 percent or less of total trade prior to liberalization.[2] They find that initially these “least traded” product categories experienced the largest increases in export shares following trade liberalization. For example, as shown in Table 1, they find that greater North American trade integration during the 1990s was associated with an increase in this share from 10 percent to 15 percent in the case of U.S. exports to Mexico and to 41 percent in the case of Canadian exports to Mexico. Adjusting for the increase in total trade, the external margin accounted for roughly 25 percent of the increased trade between Mexico and the United States, 40 percent of increased Mexican exports to Canada, and almost 100 percent of increased Canadian exports to Mexico.[3] Extensive margin effects are significant in the case of European integration as well. Exports from Sweden and Italy, for example, accounted for more than 100 percent of increased exports to their EU trade partners.

Hillberry and McDaniel (2002), using an alternative measure, find evidence of smaller, but still significant, extensive margin growth for the United States following the implementation of NAFTA. Using the methodology of Hummels and Klenow (2002), they define a country’s extensive margin as its share of world exports that occur in those product categories (measured HTS lines at the 10-digit level) in which a country exports. Other things equal, by this measure if a country concentrates its exports in a few product categories, it will have a lower extensive margin. Hillberry and McDaniel estimate that Mexican exports to the US grew by $86 billion between 1993 and 2001, of which 12.5% is attributable to greater extensive margin trade. Correspondingly, Mexican imports from the US grew by $44 billion, of which 9.7 percent occurred at the extensive margin. Their lower magnitude estimates in comparison to Kehoe and Ruhl can be attributed to their different metric: Hillberry and McDaniel define a product category as traded even if actual exports, though positive, are virtually insignificant. In addition, they focus on the effects of NAFTA per se and not of trade liberalization undertaken by Mexico in earlier years.

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[2] This approach towards determining whether a particular set of goods are not traded assumes that the cutoff depends on the *relative* importance of these goods in a country’s trade (e.g. 10 percent of total export value) rather than on whether their yearly value of trade falls below a fixed dollar-value cutoff (e.g. $500, 000).

[3] It should be pointed out that NAFTA was a continuation of Mexico’s comprehensive trade liberalization and economic reforms that started in the late 1980s. Canada’s participation in NAFTA was preceded by the 1988 Free Trade Agreement. Moreover, although NAFTA entailed an immediate reduction in various tariffs and nontariff barriers when it was enacted in 1994, most of the trade reforms under the agreement involved gradual liberalization. Consequently, economic integration in North America has been a gradual process over an extended period of time.

Table 1: Trade response to integration.

Exporting Country	Importing Country or Region	least traded goods, as share of total exports 1989	1999	total exports (mil$) 1989	1999	Increase in least traded goods exports/ increase in total exports
Canada	Mexico	0.10	0.42	525	953	0.99
Mexico	Canada	0.10	0.28	1578	5825	0.41
Mexico	US	0.10	0.17	27590	101842	0.25
US	Mexico	0.10	0.16	24969	80342	0.24
		1990	2000	1990	2000	
Sweden	EU	0.10	0.17	40959	44862	2.02
Italy	EU	0.10	0.14	111485	124438	1.44
Portugal	EU	0.10	0.19	13607	17727	0.86
France	EU	0.10	0.13	116917	190043	0.35
UK	EU	0.10	0.14	88793	153943	0.34
Spain	EU	0.10	0.16	40629	71384	0.25

Sources: Exports of least traded goods accounting for 10% or less of total trade in 1989 or 1990, from Kehoe and Ruhl (2002); total trade figures from *Direction of Trade* Yearbooks 1996, 2003; 1999 and 2000 figures deflated by US GDP goods deflator**.**
Note: Least traded goods account for 10% of total export value in 1989 or 1990 by construction. Increase in least traded goods exports relative to increase in total exports defined as col5= [col2*col4-(co11)*(col3)]/[col4-col3]

Evidence regarding quantities for EMU is more limited. But there are good theoretical reasons and prior empirical evidence for expecting the adoption of a single currency to lead to increased trade among the members of a currency union (see Rose, 2000). While the data limitations are evident, there is already some evidence that EMU has boosted intra-euro area trade since 1999 (HM Treasury, 2003). EMU-specific calculations based on a structural model incorporating multilateral resistance suggest an increase in trade as high as 40 to 60 per cent. Other studies, e.g. Bun and Klassen (2002), suggest smaller, though still, significant effects.

These results point out the need for a theoretical framework to understand trade liberalization that permits entry of new goods into the export market. We present one approach doing so in the following section. Alternatives have been proposed by Kehoe and Ruhl (2002), Ghironi and Melitz (2004), as well as others. But in addition, we propose a model that tries to account for the puzzling price evidence. Given the clear role for the extensive margin in explaining the quantity facts, our model will also consider how such an extensive margin can coincide with and even facilitate price divergence.

III. Model Specification

In this section we formulate an open economy macro model that specifies real trade frictions in the form of both per unit (iceberg) trade costs as well as a fixed cost of international trade. The model consists of two countries, home and foreign, in which each country's output consists of a distinct continuum of differentiated goods, denoted by labels H and F, respectively. Each country's goods are

indexed on the unit interval and are produced by monopolistically competitive firms using labor as the sole input in a linear (constant returns to scale) technology.
In principle, any good can be exported but there are variable costs τ and fixed costs of exporting f_X for any good, which are borne by the exporting firm. Consequently, an endogenously determined fraction will be nontraded in equilibrium. Nontraded goods are labeled *N* and traded goods *T*. Home and foreign agents consume CES aggregates of their own domestic goods and the other country's traded (export) goods. Quantities and prevailing prices for the goods varieties consumed in the foreign country are denoted by *.

There are several key assumptions in our framework. First, each country specializes in a range of goods that are unique to that country (albeit goods from different countries are substitutes) and that the continua of goods produced are exogenously given.[4] Thus, in focusing on tradability, we abstract from possible new entrants into domestic production. Second, we aggregate consumption only over mass of goods that are actually available to consumers; this mass may change over time as the number of imported tradable goods varies. In order to facilitate the construction of CES aggregates this necessitates assuming that elasticity between individual varieties of domestic and foreign goods are the same. This precludes the possibility of separate elasticities between home and foreign goods, and between traded and nontraded goods, which have often proven useful in open macro models. Third, we follow the tradition of standard open economy macro models by defining consumption aggregates as (weighted) averages of the consumptions of individual varieties, implying that consumption is invariant to the entry of new varieties .[5] This rules out the "love of variety" effect characteristic of Dixit-Stiglitz specifications which are popular in models of international trade and imply that utility rises with the number of varieties consumed.[6] The implications of having "love of variety" or not are absent from open economy macro models, where the mass of firms is assumed constant, the number of available varieties never changes, and hence the baskets of goods consumed are fixed.[7] Fourth, we permit productivity and iceberg transport costs to vary heterogeneously across goods varieties. As will be seen below, this gives our model flexibility necessary to explain the price and quantity puzzles of international economic integration trade liberalization discussed in Section II.

A. Consumption

The continuum of goods produced in each country is indexed by i on the interval $[0,1]$.[8] Let *n* denote the (endogenous) share of these in the home country that are nontraded, where goods are ordered

[4] A different approach is to allow a common set of goods to be potentially produced in all countries, and then have only the lowest-cost supplier actually export the good to each market, as in the probabilistic model of Eaton and Kortum (2002).
[5] The love of variety effect also implies that the aggregate price index falls with new varieties. This implies that the real exchange rate may move in the "wrong" direction (i.e. depreciate) if productivity gains generate entry, contrary to the prediction of the Balassa-Samuelson theory. The average price index that corresponds to our consumption index does not display this property.
[6] Kehoe (2003) points out that trade models with a love of variety specification and large home bias weights counterfactually predict that, in response to trade liberalization, the largest increases in trade should occur in sectors in which there already is significant trade.
[7] Benassy (1996) formulates a general specification with a parameter that nests "no love of variety" and "Dixit-Stiglitz love" as special cases.
[8] Note that, although each country produces a distinct set of goods, in our notation we use the same index *i* to order goods along each continuum.

such that $i \in [0, n]$ are nontraded and $i \in [n, 1]$ are traded. (Analogously for the foreign country, where n^* represents the share of foreign nontradeds.) Residents consume a basket of locally-produced goods and tradable goods imported from the other country. Consequently, the total mass of varieties of goods available for consumption in the home country is the sum of the mass of domestic varieties and of the goods exported by the foreign country, i.e. $1+(1-n^*)=2-n^*$.

Accordingly, aggregate consumption (C) can be defined as a CES aggregate of consumption of each country's own goods (C_H) and imports of the other country's traded (export) goods (C_{FT}):

$$C = \left(\left(\theta[n^*]\right)^{\frac{1}{\phi}} \left(C_H\right)^{\frac{\phi-1}{\phi}} + \left(1-\theta[n^*]\right)^{\frac{1}{\phi}} \left(C_{FT}\right)^{\frac{\phi-1}{\phi}} \right)^{\frac{\phi}{\phi-1}} \tag{1}$$

where $\phi > 1$ is the elasticity of substitution between home and foreign goods, and $\theta[n^*]$ is the own-goods bias coefficients that depends endogenously on the number of imported varieties (see the appendix for the derivation):

$$\theta[n^*] \equiv \frac{1}{2-n^*}, \quad 1-\theta[n^*] \equiv \frac{1-n^*}{2-n^*}, \quad 0 \le \theta[n^*] \le 1$$

Consumption of each country's own-good is in turn defined as a CES consumption index of its nontraded (C_{HN}) and traded own goods (C_{HT}):

$$\left(C_H\right)^{\frac{\phi-1}{\phi}} = \int_0^n \left(c_{Hi}\right)^{\frac{\phi-1}{\phi}} + \int_n^1 \left(c_{Hi}\right)^{\frac{\phi-1}{\phi}} di = \left(\frac{C_{HN}}{n}\right)^{\frac{\phi-1}{\phi}} + \left(1-n\right)\left(\frac{C_{HT}}{1-n}\right)^{\frac{\phi-1}{\phi}} \tag{2}$$

where $C_{HN} \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\phi}} \int_0^n \left(c_{Hi}\right)^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}}, \quad C_{HT} \equiv \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\phi}} \int_n^1 \left(c_{Hi}\right)^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}}$ (3, 4)

and lower cases are used to denote consumption of individual varieties *i* of each differentiated good. Again note that the elasticity of substitution among individual varieties of the home good and the foreign good is also assumed equal to ϕ.[9] At home, the *HN* goods occupy $[0, n]$ and the *HT* goods $[n, 1]$.

Analogously, the consumption indices of the foreign good imported by domestic agents C_{FT} is defined as

$$C_{FT} \equiv \left[\left(\frac{1}{1-n^*}\right)^{\frac{1}{\phi}} \int_{n^*}^1 \left(c_{Fi}\right)^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}} \tag{5}$$

B. Prices and Relative Demands

Price indexes are defined as usual for each category of goods, in correspondence to the consumption indexes above:

$$P = \left(\theta[n^*]\left(P_H\right)^{1-\phi} + \left(1-\theta[n^*]\right)\left(P_{FT}\right)^{1-\phi} \right)^{\frac{1}{1-\phi}} \tag{6}$$

[9] That is, $c_{Hi} / c_{Hj} = \left(p_{Hi} / p_{Hj}\right)^{-\phi}$, $c^*_{Fi} / c^*_{Fj} = \left(p^*_{Fi} / p^*_{Fj}\right)^{-\phi}$ for any two goods *i* and *j*.

where $P_H{}^{1-\phi} = \int_0^n \left(p_{Hi} \right)^{1-\phi} di + \int_n^1 \left(p_{Hi} \right)^{1-\phi} di = n\left(P_{HN} \right)^{1-\phi} + (1-n)\left(P_{HT} \right)^{1-\phi}$ (7)

$$P_{HN} \equiv \left(\left(\frac{1}{n} \right) \int_0^n p_{Hi}{}^{1-\phi} di \right)^{\frac{1}{1-\phi}}, \qquad P_{HT} \equiv \left(\left(\frac{1}{1-n} \right) \int_n^1 p_{Hi}{}^{1-\phi} di \right)^{\frac{1}{1-\phi}} \tag{8, 9}$$

$$P_{FT} \equiv \left(\left(\frac{1}{1-n^*} \right) \int_{n^*}^1 p_{Fi}{}^{1-\phi} di \right)^{\frac{1}{1-\phi}} \tag{10}$$

where P is the aggregate price level, P_H is the price index of all home goods, P_{HN} is the price index of nontraded home goods, P_{HT} is the price index of traded home goods, and P_{FT} is the price (to domestic residents) of imported foreign goods.

Note that the consumption and price indices imply the following relative demand functions for domestic residents:[10]

$$C_H / C = \left(\theta[n^*] \right) \left(P_H / P \right)^{-\phi}, \qquad C_{FT} / C = \left(1 - \theta[n^*] \right) \left(P_{FT} / P \right)^{-\phi} \tag{11}$$

$$C_{HN} / C_H = n\left(P_{HN} / P_H \right)^{-\phi}, \qquad C_{HT} / C_H = \left(1-n \right) \left(P_{HT} / P_H \right)^{-\phi} \tag{12}$$

and analogously for foreign residents.

C. *Production and Productivity*

The production sector in each country consists of constant-returns-to-scale technologies for the output of each differentiated good:

$$y_{Hi} = A_i l_{Hi} , \tag{13}$$

where y_{Hi} represents the level of output, l_{Hi} denote workers employed in production, and A_i are productivity coefficients for each individual good *i*. We employ the usual assumption that labor is mobile across sectors within each economy, but immobile across countries.

Profit maximization under monopolistic competition implies pricing is determined by the standard cost markup rule. For domestic sales of all home goods, either traded or nontraded goods:

$$p_{Hi} = \frac{\varphi}{\varphi - 1} \frac{W}{A_i}, \; i \in [0,1], \tag{14}$$

where W denotes the home and foreign wage rates, respectively, and $\varphi/(1-\varphi)$ is the markup factor. Note that the markup is assumed to depend on an elasticity of substitution parameter φ (constant across countries) that may differ from that across varieties of goods ϕ.[11] For export sales of traded goods,

$$p_{Hi}^* = \frac{\varphi}{\varphi - 1} \frac{W}{A_i} \frac{1}{1-\tau_i}, \; i \in [n,1], \quad p_{Fi} = \frac{\varphi}{\varphi - 1} \frac{W}{A_i} \frac{1}{1-\tau_i^*}, \; i \in \left[n^*, 1 \right] \tag{15, 16}$$

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[10] Also note that the CES specification implies for individual goods variety *i*
$c_{Hi} / C_H = \left(p_{Hi} / P_H \right)^{-\phi}$, $c_{Hi} / C_{HT} = (1-n)^{-1} \left(p_{Hi} / P_{HT} \right)^{-\phi}$, $c_{Hi}^* / C_{HT}^* = (1-n)^{-1} \left(p_{Hi}^* / P_{HT}^* \right)^{-\phi}$
and $c_{Fi}^* / C_F^* = \left(p_{Fi}^* / P_F^* \right)^{-\phi}$, $c_{Fi}^* / C_{FT}^* = \left(1-n^* \right)^{-1} \left(p_{Fi}^* / P_{FT}^* \right)^{-\phi}$, $c_{Fi} / C_{FT} = \left(1-n^* \right)^{-1} \left(p_{Fi} / P_{FT} \right)^{-\phi}$.

[11] For example, ϕ may be less than φ on the presumption that the elasticity of substitution among firms in a given sector (e.g. between Honda and Toyota) is greater than that across sectors (e.g. between autos and food).

where τ_i ($0<1-\tau_i<1$) is the fraction of each good *i* lost during shipment and it is assumed that foreign residents fully absorb these iceberg costs of shipping.[12] Thus for each traded good the foreign sales price exceeds the domestic price by the proportion $1/(1-\tau_i)>1$:

$$p_{Hi}^* = p_{Hi}\frac{1}{1-\tau_i}, \qquad p_{Fi} = p_{Fi}^*\frac{1}{1-\tau_i^*}$$

Note that, in the absence of transport costs, sales prices are equalized across markets for each good *i*, i.e. $p_{Hi}=p_{Hi}^*$, $p_{Fi}=p_{Fi}^*$.

One important feature of the model is the distribution of productivities across each country. Firms in the domestic country have a distribution of productivity levels given by $F[A_i]$. Among these firms, $n=1-F[A_n]$ are nontraders and $1-n=F[A_n]$ are exporters.

We define special weighted productivity averages for home goods $\tilde{A}$, nontraded home goods $\tilde{A}_N$, and traded home goods $\tilde{A}_T$ and their foreign analogues: [13]

$$\left(\tilde{A}\right)^{\phi-1} \equiv \int_0^1 A_i^{\phi-1}di, \tag{17}$$

$$\left(\tilde{A}_N[n]\right)^{\phi-1} \equiv \frac{1}{n}\int_0^n (A_i)^{\phi-1}di, \tag{18}$$

$$\left(\tilde{A}_T[n]\right)^{\phi-1} \equiv \left(\frac{1}{1-n}\right)\int_n^1 A_i^{\phi-1}di, \tag{19}$$

If goods are ordered with increasing productivity, then $\partial\tilde{A}_T/\partial n>0$, $\partial\tilde{A}_N/\partial n<0$, i.e. average productivity rises (falls) in the traded sector (nontraded) sector with increasing *n*. Intuitively, as the share of nontraded goods in the economy rises, goods at the low productivity end of the traded goods sector become nontraded, and the average level of productivity of all remaining traded goods rises.[14]

Transport costs may also vary heterogeneously across firms. We define the "effective" productivity of home good exports as $A_i(1-\tau_i)$, i.e. productivity adjusted by the transport costs of goods exported abroad, since higher τ effectively lowers the productivity of these goods relative to the same goods sold domestically.

We define the *average* effective productivity of home and foreign exports $\tilde{A}_{(1-\tau)T}$ as

$$\left(\tilde{A}_{(1-\tau)T}[n]\right)^{\phi-1} \equiv \left(\frac{1}{1-n}\right)\int_n^1 \left((1-\tau_i)A_i\right)^{\phi-1}di \tag{20}$$

where the "*T*" in the subscript indicates that these averages are computed over the range of goods that are traded. It is straightforward to express the price index for nontraded and traded home goods in terms of these productivity averages by using (14) to substitute for p_{Hi} in (8) and (9):

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[12] For example, if $\tau_i=0.5$, then 50% of good *i* is lost in shipment and the firm doubles the price of the good that reaches the foreign market.

[13] As pointed out by Melitz (2003), weighting by the elasticity parameter ϕ, makes the weights proportional to the relative output shares of firms.

[14] Note $\left(\tilde{A}\right)^{\phi-1} = n\left(\tilde{A}_N[n]\right)^{\phi-1} + (1-n)\left(\tilde{A}_T[n]\right)^{\phi-1}$.

$$P_{HN} = \frac{\varphi}{\varphi-1}\left(\frac{W}{\tilde{A}_N[n]}\right), \qquad P_{HT} = \left(\frac{\varphi}{\varphi-1}\right)\frac{W}{\tilde{A}_T[n]} \tag{21, 22}$$

with (7) implying

$$P_H = \frac{\varphi}{\varphi-1}\frac{W}{\tilde{A}} \tag{23}$$

Correspondingly, the price of home goods exported to foreign residents is

$$P_{HT}^{*} = \left(\frac{\varphi}{\varphi-1}\right)\frac{W}{\tilde{A}_{(1-\tau)T}[n]} \tag{24}$$

Equations (21) and (22) express the prices of nontraded and traded goods as functions of the wage rate *W*, the relevant productivity averages, and the share of nontraded goods *n*. Observe that these prices are increasing in the wage rate and decreasing in average productivity. Since $\tilde{A}$ is independent of *n*, the nontraded vs. traded goods composition of the economy affects P_H only through its effect on the average wage level in the economy. In the absence of any transport costs at all, all goods are traded ($n = 0$), implying $\tilde{A} = \tilde{A}_{(1-\tau)T} = \tilde{A}_T$, and prices of all goods are equalized: $P_H = P_{HT} = P_{HT}^{*}$. Keep in mind that n is itself an endogenous variable that will be solved as part of the general equilibrium system

D. Marginal Trading Condition

The additional profit to a home firm *i* of exporting to the foreign market may be written:

$$\pi_{Hi}^{*} = \left(p_{Hi}^{*} - \frac{W}{A_i}\frac{1}{1-\tau_i}\right)c_{Hi}^{*} - Wf_X \tag{25a}$$

where the operating profits are defined as the export price minus marginal cost, *times* the volume of sales to foreign residents. We follow Ghironi and Melitz (2004) in assuming that firms employ domestic workers to cover the fixed costs. With f_X measured in units of effective domestic labor and *W* as the wage rate of this labor, labor costs are expressed as Wf_X .[15] If this additional profit is positive, the firm will choose to export; if negative, the firm will not. This provides the condition that pins down the index of the marginal trading firm and hence the share of nontraded goods. For firm index *i* = *n* the profit from exporting is exactly zero, so

$$\left(p_{Hn}^{*} - \frac{W}{A_n}\frac{1}{1-\tau_n}\right)c_{Hn}^{*} = Wf_X \tag{25b}$$

E. Closing and Solving the Model

Labor market equilibrium in the domestic country requires that labor employed in production of nontraded and traded home goods *plus* labor employed to cover the fixed costs of exporting equal the (exogenous) domestic labor supply L_H . In the appendix we show that this condition implies the following relation[16]:

[15] In general, the effective labor employed to cover the fixed costs should depend on the productivity of the labor employed and the wage rate should be scaled by this level of productivity, which we can denote A_{fx} A_{fx} may be assumed exogenously given or related to productivity elsewhere in the economy, e.g. $\tilde{A}$, the average aggregate productivity level. We abstract from this issue by normalizing A_{fx} to 1.

[16] When all home goods are nontraded, i.e. *n* = 1, then no labor is employed to cover fixed costs of exporting.

$$WL_H - (1-n) f_X W = \left(\frac{\varphi - 1}{\varphi}\right)\left[P_H C_H + P_{HT}^* C_{HT}^*\right] \quad (26)$$

i.e. the domestic wage bill—net of wages paid for workers employed in covering fixed costs, $W(1-n) f_X$ —is proportional to the value of home goods consumed domestically or exported, with the proportionality constant equal to 1 minus the profit rate $1/\varphi$.

We close the model with the balanced trade condition that the value of exports equals the value of imports

$$P_{HT}^* C_{HT}^* = P_{FT} C_{FT} \quad (27)$$

and the normalization condition[17]

$$P^* = 1 \quad (28)$$

Equilibrium determines the 24 variables C, C_H, C_{HN}, C_{HT}, C_{FT}, P, P_H, P_{HN}, P_{HT}, P_{FT}, W, and n and their foreign counterparts (denoted by *) by solving the system of 24 equations (1)-(7), (21)-(22), (25b), and (26) plus their foreign counterparts, together with (27) and (28). In words, production markups link prices to wages. Standard CES demand conditions link prices to consumption quantities and, thence, via technology, to derived labor demand. Market clearing (including balanced trade) and the numéraire choice yield a solution conditional on given nontraded shares *n* and *n**. The marginal trading conditions render the producers of the borderline traded-nontraded good indifferent between home and foreign sales, and, given the costs of shipping, this pins down *n* and *n** in equilibrium and completes the solution.

IV. Analytical Results and Discussion

In this section we discuss some of the general insights of our framework for economic integration. In particular, we focus on illustrating the differential effects of changes in iceberg and fixed costs on cross-country price differences and trade flows. Simulations in the following section will complete the analysis and understanding of the model.[18]

A. Preliminaries: Decomposition into Homogenous and Heterogeneous Components.

Our model potentially permits heterogeneity in two different dimensions: in terms of productivity and in iceberg transport costs. In the following discussion it will prove useful to decompose productivity and iceberg transport costs for good *i* into homogenous (α) and heterogeneous (β) components. We will address two (polar) cases: (i) heterogeneity in productivity only, and (ii) heterogeneity in iceberg costs only (we report only home country expressions; the foreign country counterparts are analogous):

In the case of heterogeneity in productivity only, we may write the distributions as

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[17] An alternative normalization is $W^* = 1$.

[18] Bergin, Glick. And Taylor (2004) formulate a similar model without iceberg costs in order to investigate the effects of productivity growth on the real exchange rate and the range of goods traded. Their framework provides a more generalized approach to the Balassa-Samuelson hypothesis and its relationship to long-run growth.

$$A_i = \alpha_A \beta_A[i], \quad i \in [0,1], \qquad 0 < \alpha_A, \beta_A$$
$$1-\tau_i = \alpha_{1-\tau}, \quad i \in [0,1], \qquad 0 \le \alpha_{1-\tau} \le 1$$

implying effective productivity can be expressed as

$$A_i(1-\tau_i) = (\alpha_A \beta_A[i])\alpha_{1-\tau}.$$

Changes in $\alpha_A, \alpha_{1-\tau}$ represent balanced changes in productivity and transport costs affecting all goods equally. Note a rise in $\alpha_{1-\tau}$ implies a *decline* in iceberg costs. It follows that the productivity averages can be expressed (with the foreign counterparts defined analogously) as:

$$\tilde{A} = \alpha_A \left[\int_0^1 (\beta_A[i])^{\phi-1} di \right]^{\frac{1}{\phi-1}} \equiv \alpha_A \left(\widetilde{\beta}_A \right) \tag{29a}$$

$$\tilde{A}_T[n] = \alpha_A \left[\frac{1}{1-n} \int_n^1 (\beta_A[i])^{\phi-1} di \right]^{\frac{1}{\phi-1}} \equiv \alpha_A \left(\widetilde{\beta}_{AT}[n] \right) \tag{30a}$$

$$\tilde{A}_{(1-\tau)T}[n] = \alpha_A \alpha_{1-\tau} \left[\frac{1}{1-n} \int_n^1 (\beta_A[i])^{\phi-1} di \right]^{\frac{1}{\phi-1}} \equiv \alpha_A \alpha_{1-\tau} \left(\widetilde{\beta}_{AT}[n] \right) \tag{31a}$$

Assuming that goods are ordered with increasing productivity i.e. $\partial \beta_A / \partial i > 0$, then $\partial \widetilde{\beta}_{AT} / \partial n > 0$, $\partial \tilde{A}_T / \partial n > 0$, , i.e. average transport costs in the traded sector rise as *n* increases and the traded goods share declines.

In the alternative case of heterogeneity in transport costs only, we write the distributions

$$A_i = \alpha_A, i \in [0,1], \qquad 0 < \alpha_A$$
$$1-\tau_i = \alpha_{1-\tau} \beta_{1-\tau}[i], \; i \in [0,1], \quad 0 \le \alpha_{1-\tau}, \beta_{1-\tau} \le 1$$

implying effective productivity can be expressed as

$$A_i(1-\tau_i) = \alpha_A \left(\alpha_{1-\tau} \beta_{1-\tau}[i] \right)$$

The corresponding averages are

$$\tilde{A} = \alpha_A \tag{29b}$$

$$\tilde{A}_T[n] = \alpha_A \tag{30b}$$

$$\tilde{A}_{(1-\tau)T}[n] = \alpha_A \alpha_{1-\tau} \left[\frac{1}{1-n} \int_n^1 (\beta_{1-\tau}[i])^{\phi-1} di \right]^{\frac{1}{\phi-1}} \equiv \alpha_A \alpha_{1-\tau} \left(\widetilde{\beta}_{(1-\tau)T}[n] \right) \tag{31b}$$

Assuming that goods are ordered with *decreasing* iceberg costs, i.e. $\partial \beta_{1-\tau} / \partial i > 0$, then $\partial \widetilde{\beta}_{(1-\tau)T} / \partial n > 0$, $\partial \tilde{A}_{(1-\tau)T} / \partial n > 0$, i.e., average heterogeneity and transportability rise in the traded sector with increasing *n*.

B. Tradability

One immediate conclusion is the equivalence, in terms of their effects on tradability, of the trade cost heterogeneity that we advocate and the heterogeneity in productivity that has been the focus of other recent papers. This may be seen by considering the trading condition for firm *i* (25a), substituting out all firm-specific endogenous variables and making some additional simplifying substitutions. We use the price setting conditions (15) and (24) to substitute for p^*_{Hi} and P^*_{HT} and the relative demand condition $c^*_{Hi} / C^*_{HT} = (1-n)^{-1} \left(p^*_{Hi} / P^*_{HT} \right)^{-\phi}$ for c^*_{Hi} to find:

$$\left(A_i\left(1-\tau_i\right)\right)^{\phi-1}\left(\frac{\left(\tilde{A}_{(1-\tau)T}[n]\right)^{-\phi}C_{HT}^{*}}{(\varphi-1)(1-n)}\right)=f_X$$

In this equation, the good-specific trade cost term and that for technology appear only as a product, $A_i\left(1-\tau_i\right)$, so it is only the net effect of the two terms that matters for the relative ranking of varieties in terms of their tradability. For example, even if a good *i* is more costly to trade than a good *j*, $\tau_i>\tau_j$, good *i* nevertheless can be more tradable if it has a sufficiently high level of productivity so that $A_i(1-\tau_i)>A_j(1-\tau_j)$. Conversely, there also may be some highly productive goods that nevertheless will probably never be traded, because they have particularly high good-specific transport costs. Goods can in principle be ranked in terms of tradability using this composite metric.

We next obtain some insight into the extensive margin of trade by considering the trading condition for the marginal good (25b). Using the price setting condition (15) for p_{Hn}^{*} and noting that the relative demand condition $c_{Hi}^{*}/C_{HT}^{*}=(1-n)^{-1}\left(p_{Hi}^{*}/P_{HT}^{*}\right)^{-\phi}$ holds for all goods *i* in the range $[n,1]$:[19]

$$\left\{\frac{1}{\varphi-1}\left(\frac{1}{A_n\left(1-\tau_n\right)}\right)\right\}\left\{\left(\frac{p_{Hn}^{*}}{P_{HT}^{*}}\right)^{-\phi}\frac{C_{HT}^{*}}{1-n}\right\}=f_X \qquad (32)$$

In this form, we can infer that the *n*th firm's variable profits depend on two factors: (1) per unit export profits – the term in the first set of curlicue brackets on the LHS, expressed as a proportion $1/(\varphi-1)$ of marginal costs, and (ii) the quantity of exports sold – the term in the second set of curlicue brackets. The latter, in turn, can be decomposed into the relative price effect on demand for the *n*th firm's exports, $\left(p_{Hn}^{*}/P_{HT}^{*}\right)^{-\phi}$, and its share of the aggregate level of exports sold abroad, $C_{HT}^{*}/(1-n)$.

When variable exports profits exceed the fixed costs of exporting—either because per unit profits or the volume of exports are high – goods with effective productivity lower than that of the initial *n*th good will become traded (since even though $A_i(1-\tau_i)<A_n(1-\tau_n)$ for these goods, it has become profitable to export them). The resulting decline in *n* and rise in the share of tradable goods 1-*n* raises the marginal cost and price of the marginally traded good and reduces its share of aggregate exports. These effects cause both per unit profits and the export volume to fall. In equilibrium, profits are reduced to just covering the fixed costs of the *n*th good entering into the foreign export market.

How does economic integration affect tradability? Expression (32) gives us some insights into the differential impacts on tradability of trade liberalization in the form of a cut in iceberg costs or in fixed costs. In particular, it helps to highlight the relative changes in trade at the extensive margin, i.e. exports of newly tradable goods, and changes in trade at the intensive margin, i.e. increased exports of existing tradable goods. (Note that *W* cancels from both sides of (32).) We consider each form of liberalization in turn.

<u>Decline in per unit (iceberg) costs</u> (rise in $\alpha_{1-\tau}$, $\alpha_{1-\tau}^{*}$)

In the case of a balanced cut in tariff rates (i.e. rise in $\alpha_{1-\tau}$), the effect on export profits of the marginal trading firm is likely to be small, implying limited incentive for new entrants into the traded goods market and a limited increase in trade at the extensive margin. Several elements figure into this result. First,

[19] Note *W* can be cancelled from both sides of (32).

under monopolistic competition, firms pass on tariff changes into the sales price charged to foreign consumers (see expression (15)); consequently the lower export price implies *lower* per unit export profits for the *n*th firm. Second, because the cut in tariffs affects all traded goods equally, the relative price of the *n*th firm's exports $\left(p^*_{Hn} / P^*_{HT}\right)$ is unaffected.[20] Lastly, it is only though an increase in demand for aggregate exports C^*_{HT}, i.e. an increase in trade at the intensive margin, that the *n*th firm may experience an overall increase in export profits. If aggregate exports increase sufficiently to raise variable profits above fixed costs, then new goods may become traded and trade will increase at the extensive margin (i.e. the equilibrium *n* falls and the share of traded goods 1-*n* increases).

The increase in aggregate exports reflects increased trade at the intensive margin The amount by which aggregate exports rise depends on the elasticity of demand for exports. Considering the foreign counterpart to equation (10)

$$C^*_{HT} = (1-\theta[n])\left(P^*_{HT} / P^*\right)^{-\phi} C^*$$

we see that a per unit cost cut induces firms to lower the relative price of tradables (i.e. P^*_{HT} / P^* falls), which boosts foreign demand for home goods exported to the foreign market. It is apparent that the magnitude of increased demand for exports falls as the elasticity of demand declines. Consequently, the effect on the profits of the marginal trader and the incentive for new entrants is less as well.[21] In fact, because of the negative effects of a cut in tariffs on per unit profits, we cannot rule out the possibility that this effect dominates any increase in export volume, implying profits of the marginal trader actually decline, leading him to exit the tradables market. On balance, however, we expect profits to rise, implying some fall in *n*, and some increase in trade at the extensive margin.

<u>Decline in fixed costs</u> ($f_{X,}\ f^*_X$ fall)

Fixed trade costs only enter into the marginal trading condition; they do not enter into the decision rules about price setting or how much to produce and sell. Hence, in the case of a fixed trade cost reduction, there is a direct effect raising the export profits of the marginal exporter, since variable profits will exceed the now lower fixed costs of exports. There is no effect on per unit profits—unlike the case of a tariff cut—or the relative price of the marginal exporter. The positive export profits for the marginal trader leads to an increase in trade at the extensive margin (i.e. decline in *n*) as it becomes profitable for new goods to enter the traded sector.

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[20] These effects can be seen more clearly by noting that (29)-(31) imply (32) may be expressed as

$\left\{\frac{1}{\varphi-1}\left(\frac{1}{\alpha_A \alpha_{1-\tau}\beta_{1-\tau}[n]}\right)\right\}\left\{\left(\frac{\tilde{\beta}_{(1-\tau)T}[n]}{\beta_{1-\tau}[n]}\right)^{-\phi}\left(\frac{C^*_{HT}}{1-n}\right)\right\} = f_X$ with productivity heterogeneity only, and

$\left\{\frac{1}{\varphi-1}\left(\frac{1}{\alpha_A \alpha_{1-\tau}\beta_A[n]}\right)\right\}\left\{\left(\frac{\tilde{\beta}_{AT}[n]}{\beta_A[n]}\right)^{-\phi}\left(\frac{C^*_{HT}}{1-n}\right)\right\} = f_X$ with transport cost heterogeneity only.

[21] We conjecture that this is most likely to occur as one approaches the limiting case of Cobb-Douglas preferences between home and foreign goods, where elasticity for imports is unity. In our current specification with endogenous home bias weights, however, we are precluded from considering this case because of the constraint that the elasticity between home and foreign goods be the same as that among individual varieties of home (and foreign) goods, which must exceed unity with CES preferences. With exogenous home bias weights, this constraint can be dropped and the different elasticities can be posited.

To summarize, a cut in fixed costs will work largely through the entry of new goods into the traded sector, implying greater trade at the extensive margin. In contrast, a cut in per-unit trade costs will tend to raise exports mostly through increasing the intensity of trade in previously traded goods; i.e. firms already trading, will export more. The extensive effect on trade is dampened in this case because lower marginal costs lead to proportionately lower prices, and hence lower per unit profits from exporting. This limits the extent to which new firms find it profitable to engage in exporting.

C. Law of One Price and Price Divergence

We next examine the circumstances under which deviations from the law of one price may emerge in our model. At the level of individual goods *i*, it is immediately apparent that monopolistic pricing—see expressions (15) and (16)—implies the export price exceeds the domestic price of good *i* by a wedge associated with transport costs:

$$\frac{p_{Hi}^{*}}{p_{Hi}}=\frac{1}{1-\tau_i}=\frac{1}{\alpha_{1-\tau}\beta_{1-\tau}[i]}>1, \quad i\in[n,1]$$

With homogeneous trade costs the degree of price divergence is constant across sectors. However, if $\beta_{1-\tau}[i]$ and $1-\tau_i$ vary with *i*, the degree of price divergence varies with *i* as well. Thus variations across sectors in the degree of LOP deviations depend on the presence of heterogeneous transport costs; with monopolistic pricing, heterogeneous productivity is not sufficient.

What about cross-border deviations in *average* tradable prices? Expressions (22) and (24) together with (19) and (20) imply

$$\frac{P_{HT}^{*}}{P_{HT}}=\frac{\tilde{A}_T[n]}{\tilde{A}_{(1-\tau)T}[n]}>1 \qquad (33)$$

since the presence of transport costs implies $\tilde{A}_T>\tilde{A}_{(1-\tau)T}$, i.e. the average *effective* productivity of tradable goods (i.e., including transport costs) is less than the average productivity of tradable goods. Consequently, the average price to foreign residents of exported home goods is higher than the average domestic price of the same goods at home.

How does economic integration affect price deviations? The answer depends on the form of liberalization – iceberg transport costs or fixed trade costs—and on whether heterogeneity exits in the form of productivity or iceberg costs. We know from the previous section that both forms of liberalization induce some increase in trade at the extensive margin, i.e. decline in n, with this increase being greater in the case of a fixed trade cost reduction. As we shall see, the effect on trade liberalization depends on how the endogenous change in the degree of tradability interacts with the nature of heterogeneity. We again consider the effects of cuts in iceberg costs and in fixed costs in turn.

<u>Decline in iceberg costs (</u> $\alpha_{1-\tau}, \alpha_{1-\tau}^{*}$ rise)

In the case of productivity heterogeneity, (30a) and (31a) imply (33) reduces to

$$\frac{P_{HT}^{*}}{P_{HT}}=\frac{1}{\alpha_{1-\tau}}\ , \qquad (34)$$

indicating that deviations from LOP at the aggregate level depend only on the homogenous transport cost parameter $\alpha_{1-\tau}$, An increase in $\alpha_{1-\tau}$, i.e. balanced decrease in transport costs, implies a fall in P_{HT}^{*}/P_{HT} and reduces the average deviation from LOP.

In the case of transport cost heterogeneity, (33) reduces to

$$\frac{P^*_{HT}}{P_{HT}} = \frac{1}{\alpha_{1-\tau}\widetilde{\beta}_{1-\tau}[n]} \ , \tag{35}$$

and deviations from LOP at the aggregate level depend on the relative heterogeneity of transport costs ($\widetilde{\beta}_{(1-\tau)T}$) as well as on the homogeneous transport cost component ($\alpha_{1-\tau}$). The direct effect of a homogenous cut in costs (i.e. increase in $\alpha_{1-\tau}$) is to reduce price divergence. But there is also a potentially offsetting effect to consider through the endogenous changes in tradability on the heterogeneous component of transport costs. Specifically, a decrease in *n,* implying an increase in the number of tradable varieties, implies that trade costs are averaged over goods with higher costs. i.e., lower $1-\tau_i$. The resulting fall in $\widetilde{\beta}_{1-\tau}[n]$ (since $\partial\widetilde{\beta}_{1-\tau}[n]/\partial n > 0$) raises the degree of price divergence. Our simulation exercises (in Section 5) reveal that the latter effect is dominated by the direct effect of the cut in costs, and price divergence falls on balance.

<u>Decline in fixed costs ($f_{X,}$ f_X^* fall)</u>

Fixed costs do not affect deviations from LOP at the sector level, but they can affect deviations at aggregate level to extent they affect *n*. In the case of productivity heterogeneity, the relation (34) applies, and the degree of price divergence is unaffected by any change in fixed costs. Intuitively, given that price setting is determined by per unit costs and not fixed costs, a cut in fixed costs has no effect on export prices. Thus in this case there is no reason to expect prices to converge as the economies become more integrated.

However, in the presence of transport cost heterogeneity, (35) holds and deviations from LOP depend on the heterogeneity of transport costs ($\widetilde{\beta}_{(1-\tau)T}$) as well homogeneous transport costs ($\alpha_{1-\tau}$). In this case a decline in fixed costs that fosters decreased *n* and increased tradability, reduces $\widetilde{\beta}_{1-\tau}[n]$ and raises price disparity. In words, if the source of heterogeneity is in terms of iceberg costs, then the newly tradable goods systematically will be those goods with higher per unit costs. Given the lower fixed costs, it now becomes profitable to trade these goods, despite the higher per unit costs. Given that price setting responds to these costs, the newly traded goods will tend to have a greater price wedge between national markets, so that average price dispersion of all traded goods will increase.

To sum up, iceberg costs play an important role in explaining market segmentation as measured in terms of price deviations, because fixed costs have no impact on the pricing behavior of monopolistically competitive firms. Cuts in iceberg costs reduce price disparities across markets. Moreover, only heterogeneity in iceberg costs can explain heterogeneity of LOP deviations. In contrast, fixed trade costs reductions *in the presence of transport cost heterogeneity* can explain why price divergence may actually increase when account is taken of endogenous changes in the tradability of goods.

D. Trade Quantities

Integration measured through trade quantities also depend on transport and fixed costs of exporting. Balanced trade (see (27)) implies that exports and imports as ratios of total aggregate consumption are equal:

$$\frac{P^*_{HT}C^*_{HT}}{PC} = \frac{P_{FT}C_{FT}}{PC}$$

From the relative demand conditions (11, 11*):

$$\frac{P^*_{HT}C^*_{HT}}{PC} = \left(1-\theta^*[n]\right)\left(\frac{P^*_{HT}}{P^*}\right)^{1-\phi}, \frac{P_{FT}C_{FT}}{PC} = \left(1-\theta[n^*]\right)\left(\frac{P_{FT}}{P}\right)^{1-\phi} \qquad (36, 36^*)$$

implying that exports relative to consumption—which equals GDP in our single period—depend on two factors: the relative import price for foreign residents P^*_{HT}/P^* and the (ii) foreign bias coefficient for imported home goods $1-\theta^*[n]$. A decrease in the relative price of imports and/or an increase in bias towards imports raises the home country's exports.

How does trade liberalization affect exports? We proceed by considering first a reduction in iceberg costs and then a reduction in fixed costs. We assume a symmetric steady state which, because the foreign aggregate price level is normalized to unity, implies $P = P^* = 1$. We also assume that changes are symmetric across countries and lead to equal declines in *n, n** and hence increases in the number of tradable varieties. Because of the symmetric nature of the experiment, relative aggregate prices remain constant and equal to unity as well. Hence we may infer the change in relative prices solely from the change in P_{FT} given by (24):

$$P^*_{HT} = \left(\frac{\varphi}{\varphi-1}\right)\frac{W}{\tilde{A}_{(1-\tau)T}[n]} \qquad (24)$$

For reference, we express this price in terms of the relevant productivity averages when productivity is heterogeneous

$$P^*_{HT} = \frac{\varphi}{\varphi-1}\left(\frac{W}{\alpha_{1-\tau}\alpha_A\tilde{\beta}^*_{AT}[n]}\right),$$

and when transport costs are heterogeneous

$$P^*_{HT} = \frac{\varphi}{\varphi-1}\left(\frac{W}{\alpha_{1-\tau}\alpha_A\tilde{\beta}_{(1-\tau)T}[n]}\right).$$

<u>Decline in iceberg costs (</u> $\alpha_{1-\tau}, \alpha^*_{1-\tau}$ rise)

A fall in iceberg costs (increase in $\alpha_{1-\tau}$) directly reduces the price of goods exported to foreign residents, increases demand, and raises the home country's level of exports. But there is an opposing effect, as falling *n* and increased trade at the extensive margin imply goods with either lower effective productivity or higher transport costs become traded, raising the average price of imported goods.[22] Wages *W* rise as well because of increased demand for labor to produce the greater export volume. But simulations (see the next section) indicate that these effects are not enough to offset the impact effect of the increase in $\alpha_{1-\tau}$.[23] The net decline in the price of imports implies exports rise. The effect on θ^* reinforces this

---

[22] Mathematically, since $\partial\tilde{\beta}^*_{AT}/\partial n^* > 0$, $\partial\tilde{\beta}^*_{(1-\tau)T}/\partial n > 0$, the fall in *n* implies that $\tilde{\beta}^*_{AT}[n^*]$, $\tilde{\beta}^*_{(1-\tau)T}[n^*]$ both decline.

[23] Partially differentiating $\partial\left(P^*_{HT}\right) = -\left(P^*_{HT}/\alpha_{1-\tau}\right)\partial\alpha_{1-\tau} + \left(1/\alpha_{1-\tau}\right)\partial\left(W/\tilde{\beta}_X[n\ ]\right)$. The first term is negative, while the second term is positive. Simulations indicate that the first effect dominates.

effect: as more varieties become traded, the weight placed on imported goods in the foreign price index increases, and the relative demand by foreign residents for imported goods in their consumption basket rises.[24]

Decline in fixed costs ($f_{X,}\ f_X^*$ fall)

With a fixed cost reduction, there is no direct effect on the relative price of goods exports to foreigners. However, the decline in *n* also implies goods with lower effective productivity or higher transport costs become traded, raising the average price of exported goods.[25] However, *W* falls in this case since less labor is needed to cover the fixed costs of exporting. Our simulations imply this effect is second order and P_{HT}^* rises on balance. Thus the rise in the price in response to the cut of fixed costs works to reduce home country exports. However, the effect on θ^* works in the opposite direction, as the increase in imported varieties raises the demand by foreigners for home country exports. This increases the level of home country exports $P_{HT}^* C_{HT}^*$. Overall, we find that the latter effect dominates and that exports as a share of GDP rise, but by less than in the case of a per unit cost decline.

V. Numerical Results

A. Calibrations

In several of the cases discussed above, trade liberalization had ambiguous effects, due to the fact that they involved multiple effects, sometimes working in offsetting directions. In part to help resolve these ambiguities, we use numerical simulations below.

Simulations calibrate the parameter ϕ at the value 6. This parameter represents the elasticity between any two varieties, and is set to reflect a price markup over cost of 0.2, which is a common value used in the literature (see Obstfeld and Rogoff, 2000). Note that this elasticity also doubles as the elasticity between home and foreign goods. Recent work suggests that this elasticity might be lower than 6, but as discussed earlier in the paper, separating these two elasticities is difficult when the set of home goods exported is allowed to change endogenously.

Simulations require that particular distributions be specified for the heterogeneous elements. Productivity will follow the distribution:

$$A_i = \alpha_A (1+i)^{\beta_A}, \qquad i \in [0,1], \qquad 0 < \alpha_A$$

and iceberg costs follow the distribution

$$1-\tau_i = \alpha_{1-\tau} (1+i)^{\beta_{1-\tau}}, \quad i \in [0,1], \qquad 0 \le \alpha_{1-\tau}$$

24 Since $\partial\theta^* / \partial n > 0$ (recall $\theta^*[n] = 1/(2-n)$), a decrease in n, i.e. an increase in tradables varieties, decreases θ^* and raises $1-\theta^*$.

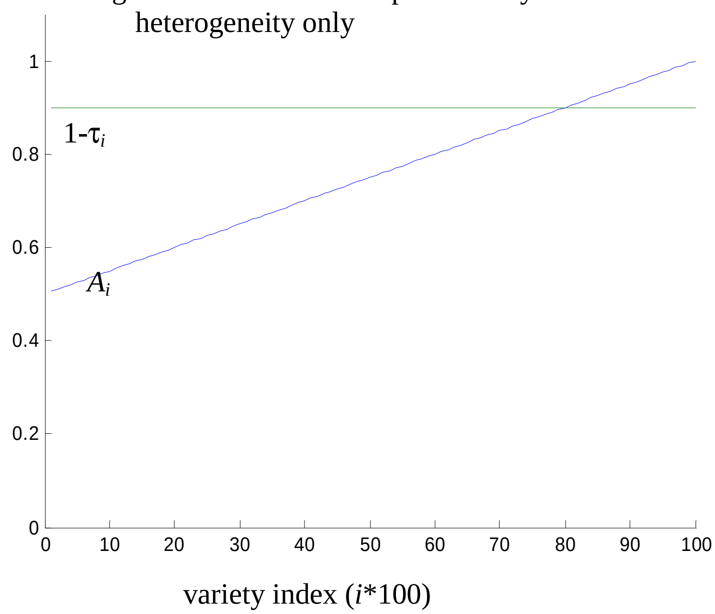
25 Mathematically, since $\partial\widetilde{\beta}_{AT}^* / \partial n^* > 0$, $\partial\widetilde{\beta}_{(1-\tau)T}^* / \partial n > 0$ the fall in *n* implies the terms in the denominator $\widetilde{\beta}_{AT}^*[n^*]$, $\widetilde{\beta}_{(1-\tau)T}^*[n^*]$ decline.

Where α_A and $\alpha_{1-\tau}$ are scale parameters representing level effects common to all goods, while β_A and $\beta_{1-\tau}$ are parameters indicating the degree of heterogeneity over firms along the continuum indexed by *i*.

B. *Per Unit Cost Reductions*

The first simulation will consider the case where the source of heterogeneity is productivity, with distribution parameters set at $\alpha_A = 0.5$, $\beta_A = 1$, and $\alpha_{1-\tau} = 0.9$, $\beta_{1-\tau} = 0$. This implies a constant per-unit trade cost a bit over 10% for all firms, which could be interpreted as a tariff rate. Figure 2 illustrates the distributions for technology and iceberg costs over the continuum of home goods. The experiment will be to consider a rise in $\alpha_{1-\tau}$ one percent, which lifts the $1-\tau_i$ line for all varieties. This could be viewed as a 10% reduction in the approximately 10% tariff rate above. To ensure a share of nontraded goods near fifty percent, the fixed cost f_x is calibrated at 0.056. The foreign country is exactly symmetric.

Fig. 2: Distributions with productivity heterogeneity only



The results of this experiment are shown in table 2, where column 1 reports initial values before the tariff reduction. The export share less than one half indicates some degree of home bias in consumption, arising from the presence of trade costs that make imported goods more expensive than domestic goods. Column two reports the percentage change from steady state values after the tariff reduction. The finding in the analytical section regarding clear convergence in relative prices is confirmed in the last line of the table. The ten percent reduction of per unit costs, which themselves are ten percent of goods' value, amount to a one percent reduction in per unit cost, which directly translates into an exactly 1% reduction in the price deviation of home traded goods across countries. The last column of the table shows percent changes from steady state if the share of nontraded goods is assumed to be exogenous at the steady state level. This column makes clear that this simple price convergence result does not depend upon entry of new firms into exporting.

Table 2: Cut in per unit costs, with productivity heterogeneity

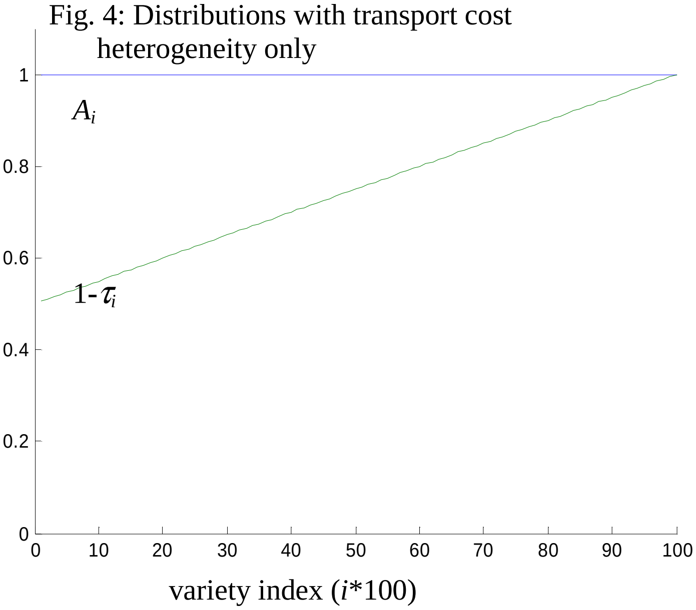
	steady state	% change (endogenous *n*)	% change (exogenous *n*)
n	0.50	-1.80	0.00
Export share[1]	0.33	3.92	3.40
Extensive share[2]	--	0.20	0.00
P_{HT}^{*} / P_{HT}	1.11	-1.00	-1.00

[1]Export share: value of exports as ratio to GDP
[2]Extensive share: fraction of new import value due to new entrants
Calibration: $\beta_A = 1$, $\alpha_A = 0.5$, $\beta_{1-\tau} = 0$, $\alpha_{1-\tau} = 0.9$, $\phi = \varphi = 6$, $f_X = 0.056$.

One ambiguity in the analytical solution is the degree of entry and increase in trade share. While the fall in export prices raises foreign demand for home exports, thereby increasing the profitability of paying the fixed cost of exporting, any new entrants will have systematically lower productivity and hence higher prices than the average among previous entrants. Line one of the table shows that there indeed is entry of new exporters, as the share of nontraded goods (*n*) falls. Line two shows that this enhances the increase in trade volume, compared to the case where there was no entry shown in the last column. But line three shows that the contribution of this extensive margin shift is relatively modest, accounting for 20 percent of the increased trade.

Next, we explore the effects of assuming heterogeneity in terms of transport costs instead of productivities. Distribution parameters in this case are: $\alpha_A = 1$, $\beta_A = 0$, $\alpha_{1-\tau} = 0.5$ and $\beta_{1-\tau} = 1$; figure 3 illustrates the distributions. Again consider an experiment where $\alpha_{1-\tau}$ rises one percent, representing a tariff cut that raises the $1-\tau_i$ line for all varieties.

Fig. 4: Distributions with transport cost heterogeneity only



The effects of the tariff cut on quantity variables here under transport cost heterogeneity are qualitatively similar to those under productivity heterogeneity above; see table 3. Once again there is entry at the extensive margin which enhances export volume; once again the contribution of the extensive margin is modest, here contributing 20% of the rise in trade. But the response of price dispersion differs from the case above, in that a 1% tariff reduction no longer translates into a full 1% reduction in price deviations. Now there is only a 0.75 percent point reduction, due to the fact that the new entrants systematically have higher iceberg costs than the average trader, thus putting upward pressure on the average. While this effect moderates the degree of price convergence, it does not dominate, and on net there is positive price convergence.

Table 3: Cut in per unit costs, with transport cost heterogeneity

	steady state	% change (endogenous n)	% change (exogenous n)
n	0.53	-2.12	0.00
Export share[1]	0.21	4.88	4.02
Extensive share[2]	--	0.23	0.00
P^*_{HT} / P_{HT}	1.12	-0.75	-1.00

[1] Export share: value of exports as ratio to GDP
[2] Extensive share: fraction of new import value due to new entrants
Calibration: $\beta_A = 0,\ \alpha_A = 1,\ \beta_{1-\tau} = 1,\ \alpha_{1-\tau} = 0.5,\ \phi = \varphi = 6,\ f_X = 0.04.$

C. Fixed Cost Reduction

Consider next experiments that instead reduce the fixed cost of trade. The two cases will use the same pair of distributions graphed in previous section, and this will imply that the starting values for our variables in the tables below will be the same as those in the two tables above. The experiment will be a reduction in the term f_X by 10%.

First, compare fixed versus per-unit cost cuts for the case of technological heterogeneity. The most striking feature in table 4 below is that there is no price convergence, confirming the finding in the analytical results in the previous section. Simulations have more new things to say about quantities, since these are more ambiguous in the analytics. Comparing table 3 to table 1, we can confirm the conjecture that there should be much more entry into exporting. However, despite this greater extensive margin growth, the overall export share in GDP rises less. This is because as new firms enter the market, firms previously trading experience an actual decline in their share of the export market. This implies the intensive margin growth is smaller, so that the share of new trade due the extensive margin exceeds 100%.

Table 4: Cut in fixed cost of trade, with productivity heterogeneity

	steady state	% change (endogenous *n*)	% change (exogenous *n*)
n	0.50	-5.85	0.00
Export share[1]	0.33	1.62	0.00
Extensive share[2]	--	1.68	0.00
P_{HT}^{*} / P_{HT}	1.11	0.00	0.00

[1]Export share: value of exports as ratio to GDP
[2]Extensive share: fraction of new import value due to new entrants
Calibration: $\beta_A = 1,\ \alpha_A = 0.5,\ \beta_{1-\tau} = 0,\ \alpha_{1-\tau} = 0.9,\ \phi = \varphi = 6,\ f_X = 0.056.$

Under transport cost heterogeneity (see figure 5) the price implications are even more dramatic. Once again the extensive margin effect drives the rise in overall trade. As conjectured in the analytics, the new entrants systematically have a greater price wedge, and because the extensive margin dominates here, there is actual price divergence on average.

Table 5: Cut in fixed cost of trade, with transport cost heterogeneity

	steady state	% change (endogenous *n*)	% change (exogenous *n*)
n	0.53	-5.76	0.00
Export share[1]	0.21	2.18	0.00
Extensive share[2]	--	1.49	0.00
P_{HT}^{*} / P_{HT}	1.12	0.69	0.00

[1]Export share: value of exports as ratio to GDP
[2]Extensive share: fraction of new import value due to new entrants
Calibration: $\beta_A = 0,\ \alpha_A = 1,\ \beta_{1-\tau} = 1,\ \alpha_{1-\tau} = 0.5,\ \phi = \varphi = 6,\ f_X = 0.04.$

D. Productivity Growth

The results above highlight the importance of fixed costs of trade in determining the degree of international integration. One might wonder what would happen to the impact of this given fixed cost as economies grow and productivity rises. Would it become easier to pay the fixed cost, so that more firms would find it profitable to engage in trade? Would this mean that a growing world would naturally tend to become more integrated?

Answering this question is not difficult, but it relies upon more than just a straight comparison of a fixed cost and average productivity, Since the fixed cost of trade here involves labor, the answer is affected by wage movements. Given that this relies upon a general equilibrium solution including the labor market conditions, it may be tedious to answer this question analytically in this model. But simulations provide a clear answer. The experiment considered is a 10% rise in the level coefficient for technology, α_A. Regardless of the source of heterogeneity, the rise in technology will raise the wage rate the same percentage. So the impact of the trade costs rises in proportion with the ability of firms to pay them. There is no new entry. Demand for all goods rises in proportion, so there is a 10% rise in exports, but this leaves the share of trade to GDP unchanged.

VI. Concluding Remarks

This paper suggests a new approach for thinking about international macroeconomic segmentation and integration. Empirical evidence suggests that price convergence and trade volume expansion, two common measures for goods market integration, need not coincide. Recent efforts to promote economic integration in Europe and in North America seem to have prompted significant increases in trade volume, much of it on the extensive margin. But there appears to be very little price convergence, and some evidence suggests price divergence for many traded goods.

We propose a model of economic integration that is more general in its implications, and which can explain a range of varied relationships between price and quantities. The model relied upon two distinctive features. First, as an alternative to heterogeneity in productivity, it allows for heterogeneity in terms of iceberg trade costs, where the reason some goods are not traded is that these goods tend to have higher costs of trade. This feature is motivated by recent empirical work in the trade literature (Hummels 1999, 2001; Anderson and van Wincoop, 2003) which emphasize that trade costs vary greatly across classes of goods and play an important role in trade decisions. The existence of heterogeneous trade costs implies that when goods market integration promotes new trade in the extensive margin, the new entrants systematically have higher per unit trade costs than average trading firms. Since it is per-unit trade costs that create price wedges between national markets, the new entrants into export markets put upward pressure on the average price wedge, possibly increasing price divergence.

The second model feature is the distinction between fixed costs and per unit costs of trade. If trade reform exclusively takes the form of lower tariffs paid on a per unit bases, this tends to lower the price wedge for all goods. However, if the reform takes the form of mainly a cut in the fixed costs of trade, then it has no effect on the price-setting of goods, and there is no effect on the price wedge between countries.

In different combinations, these features permit a range of degrees of price convergence. First, a tariff cut without trade-cost heterogeneity implies price convergence, which is the standard result of the literature. Next, the introduction of trade-cost heterogeneity limits this price convergence, but tends not to reverse it. Further, if trade reform takes the form of fixed cost cuts, then there will be no price convergence. Finally, when both features are combined, the model predicts actual price divergence driven by goods market integration.

While these features are useful theoretical devices for explaining the range of price and quantity evidence in the empirical literature, we also suspect that they have relevance for recent episodes of integration. It appears likely that recent episodes of integration have involved significant reductions in fixed cost components, beyond tariff cuts or other costs that depend directly on the number of units traded. Regarding NAFTA, McDaniel and Agama (2003) note “Tariff cuts were an important component of the agreement but the non-tariff-related provisions were arguably just as important in expanding economic ties among the members.” Examples include creation of dispute resolution mechanisms, provisions to protect foreign investment property rights, and protection of intellectual property rights. EMU might also involve significant fixed-cost reductions, in that it eliminates the need to have a unit for operations in the foreign exchange market to arrange currency hedging. Regarding EMU, Engel and

Rogers (2004) note: “If producers believe there will be greater integration of macroeconomic and microeconomic policies, they will be willing to undertake the large fixed costs involved with exporting products abroad…investment in opening foreign offices, training foreign sales representatives, and monitoring foreign sales…”

However, given that large fixed cost cuts were likely related to earlier EU integration, when there appears to have been positive price convergence, we suspect that fixed costs by themselves cannot provide a full explanation for the patterns in the data. Most integration episodes likely involve a combination of both per-unit and fixed cost cuts. In addition, the characteristics of new entrants to trade may also vary over time and across integration episodes. This calls for further microeconomic research on the characteristics of newly traded goods.

Our theoretical research also raises a fundamental question regarding the appropriate metric for gauging international integration policies. Most past research has seemed to prefer price-based measures, due to fundamental problems with quantity-based alternatives. As Engel and Rogers (1998) note, the problem with using trade flows as a measure is that the amount of trade depends also on things like factor endowments and opportunities for scale economies. So the fact that impediments to trade are small may not necessarily imply that the volume of trade will be large. Price measures do not have this problem, but our model indicates that they might suffer from other fundamental problems. Firstly, since a reduction in segmentation due to fixed costs has no bearing on price decisions, and secondly, if new entrants differ from previously existing traded goods, integration in the form of the extensive margin may imply forces working against price convergence. This calls for further research to find good metrics of international economic integration.

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Appendix

A.1. Derivation of Consumption Aggregate Expression (1, 1*) with Endogenous Bias Weights

To derive (1), define consumption by domestic resident of the home good and foreign traded good as $c_{Hi},\ i\in[0,1]$, and $c_{FTi},\ i\in\left[0,1-n^*\right]$, respectively. We index all goods available for consumption in the domestic country by *j* on the interval $\left[0,2-n^*\right]$, and order consumption as $c_j = c_{Hi}$ for $j=i\in[0,1]$, and $c_j = c_{Fi}$ for $j=i+1,\ \ j\in\left[1,2-n^*\right],\ i\in\left[0,1-n^*\right]$. Accordingly, assuming the elasticity of substitution between all varieties, domestic or foreign, is the constant ϕ, we define aggregate consumption as

$$
\begin{aligned}
C^{\frac{\phi-1}{\phi}} &= \left(\frac{1}{2-n^*}\right)^{\frac{1}{\phi}}\left[\int_0^1 (c_i)^{\frac{\phi-1}{\phi}}di + \int_1^{2-n^*}(c_i)^{\frac{\phi-1}{\phi}}di\right] \\
&= \left(\frac{1}{2-n^*}\right)^{\frac{1}{\phi}}\left(\frac{1}{1}\right)^{\frac{1}{\phi}}\int_0^1 (c_i)^{\frac{\phi-1}{\phi}}di + \left(\frac{1-n^*}{2-n^*}\right)^{\frac{1}{\phi}}\left(\frac{1}{1-n^*}\right)^{\frac{1}{\phi}}\int_1^{2-n^*}(c_i)^{\frac{\phi-1}{\phi}}di \\
&= \left(\frac{1}{2-n^*}\right)^{\frac{1}{\phi}}(C_H)^{\frac{\phi-1}{\phi}} + \left(\frac{1-n^*}{2-n^*}\right)^{\frac{1}{\phi}}(C_{FT})^{\frac{\phi-1}{\phi}} \\
&= \left(\theta[n^*]\right)^{\frac{1}{\phi}}(C_H)^{\frac{\phi-1}{\phi}} + \left(1-\theta[n^*]\right)^{\frac{1}{\phi}}(C_{FT})^{\frac{\phi-1}{\phi}}
\end{aligned}
$$

where $\theta[n^*]\equiv\dfrac{1}{2-n^*},\quad 1-\theta[n^*]\equiv\dfrac{1-n^*}{2-n^*},\quad 0\le\theta[n^*]\le 1$. The derivation of (1*) is analogous.

A.2. Derivation of Labor Market Equilibrium Condition (26, 26*)

Labor market equilibrium in the domestic country requires that labor employed in production of nontraded and traded home goods *plus* labor employed to cover the fixed costs of exporting equal the (exogenous) domestic labor supply L_H :[26]

$$
\int_0^n l_{Hi}di + \int_n^1 l_{Hi}di + (1-n)f_X = L_H
$$

Substituting for l_{Hi} with the production function (13):

$$
\int_0^n \frac{y_{Hi}}{A_i}di + \int_n^1 \frac{y_{Hi}}{A_i}di + (1-n)f_X = L_H \quad \text{or}
$$

$$
\int_0^n \frac{c_{Hi}}{A_i}di + \int_n^1 \frac{c_{Hi}+\dfrac{c^*_{Hi}}{1-\tau_i}}{A_i}di + (1-n)f_X = L_H
$$

[26] When all home goods are nontraded, i.e. *n* = 1, then no labor is employed to cover fixed costs of exporting.

since $y_{Hi} = c_{Hi}$ for $i \in [0,n]$, $y_{Hi} = c_{Hi} + \dfrac{c^*_{Hi}}{1-\tau_i}$ for $i \in [n,1]$. Substituting with $c_{Hi} / C_H = \left(p_{Hi} / P_H\right)^{-\phi}$ and $c^*_{Hi} / C^*_{HT} = (1-n)^{-1}\left(p^*_{Hi} / P^*_{HT}\right)^{-\phi}$ gives

$$\int_0^n \frac{C_H}{A_i}\left(\frac{p_{Hi}}{P_H}\right)^{-\phi} di + \int_n^1 \left(\frac{1}{A_i}\right)\left[C_H\left(\frac{p_{Hi}}{P_H}\right)^{-\phi} + \frac{1}{1-\tau_i}\left(\frac{1}{1-n}\right)C^*_{HT}\left(\frac{p^*_{Hi}}{P^*_{HT}}\right)^{-\phi}\right] di \;+\; (1-n)\,f_X = L_H$$

Using (14) and (15) in turn to substitute for p_{Hi}, p^*_{Hi} and (17) and (20) to substitute for the definitions of $\tilde{A}$, $\tilde{A}_{(1-\tau)T}[n]$ gives

$$W = \left(L_H - (1-n)\,f_X\right)^{-1/\phi}\left(\frac{\varphi-1}{\varphi}\right)\left[\left(\frac{P_H C_H}{\left(P_H\right)^{1-\phi}}\right)\left(\tilde{A}\right)^{\phi-1} + \left(\frac{P^*_{HT}C^*_{HT}}{\left(P^*_{HT}\right)^{1-\phi}}\right)\left(\tilde{A}_{(1-\tau)T}[n]\right)^{\phi-1}\right]^{\frac{1}{\phi}}$$

Substituting for P_H, P^*_{HT} with (23), (24) and canceling terms gives (26)

$$W = \left(L_H - (1-n)\,f_X\right)^{-1/\phi}\left(\frac{\varphi-1}{\varphi}\right)\left[\left(\frac{P_H C_H}{\left(\dfrac{\varphi}{\varphi-1}\dfrac{W}{\tilde{A}}\right)^{1-\phi}}\right)\left(\tilde{A}\right)^{\phi-1} + \left(\frac{P^*_{HT}C^*_{HT}}{\left(\dfrac{\varphi}{\varphi-1}\dfrac{W}{\tilde{A}_{(1-\tau)T}[n]}\right)^{1-\phi}}\right)\left(\tilde{A}_{(1-\tau)T}[n]\right)^{\phi-1}\right]^{\frac{1}{\phi}}$$

Correspondingly, for the foreign country

$$W^* = \left(L_F - (1-n^*)\,f^*_X\right)^{-1/\phi}\left(\frac{\varphi-1}{\varphi}\right)\left[\left(\frac{P^*_F C^*_F}{\left(P^*_F\right)^{1-\phi}}\right)\left(\tilde{A}^*\right)^{\phi-1} + \left(\frac{P_{FT} C_{FT}}{\left(P_{FT}\right)^{1-\phi}}\right)\left(\tilde{A}^*_{(1-\tau)T}[n^*]\right)^{\phi-1}\right]^{\frac{1}{\phi}} \qquad (26^*)$$